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**Skubitz**

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(54) **UTILIZING MULTIPLE LINKS TO ACHIEVE  
A DESIRED TOOL DEFLECTION ANGLE  
WHEN CLEARING AN EPIDURAL SPACE**

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A61B 2017/2905; A61B 2017/320044  
See application file for complete search history.

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(56) **References Cited**

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U.S. PATENT DOCUMENTS

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**A61B 17/32** (2006.01)

**A61B 17/34** (2006.01)

**A61B 17/29** (2006.01)

(52) **U.S. Cl.**

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(58) **Field of Classification Search**

CPC ..... A61B 17/16; A61B 17/32; A61B

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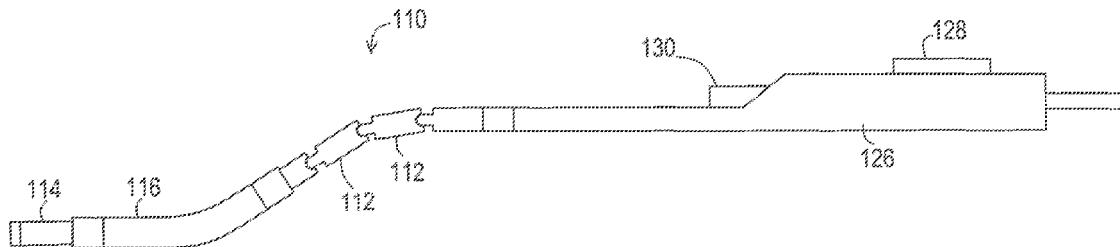
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**ABSTRACT**

An epidural space is cleared of fat and scar tissue in preparation for implantation of a medical lead by utilizing a clearing tool. The clearing tool has multiple links that allow the creation of a deflection angle. A wire passes through the links and once the links are positioned with the desired deflection angle, tension is placed on the wire to lock the links into the current position. The clearing tool is inserted through a window into the epidural space, and once the tension is applied to the wire, the clearing tool becomes rigid to allow advancement of the clearing tool within the epidural space. The clearing tool is then removed from the epidural space, and the medical lead is inserted through the window and cleared epidural space until reaching the target site.

**16 Claims, 7 Drawing Sheets**



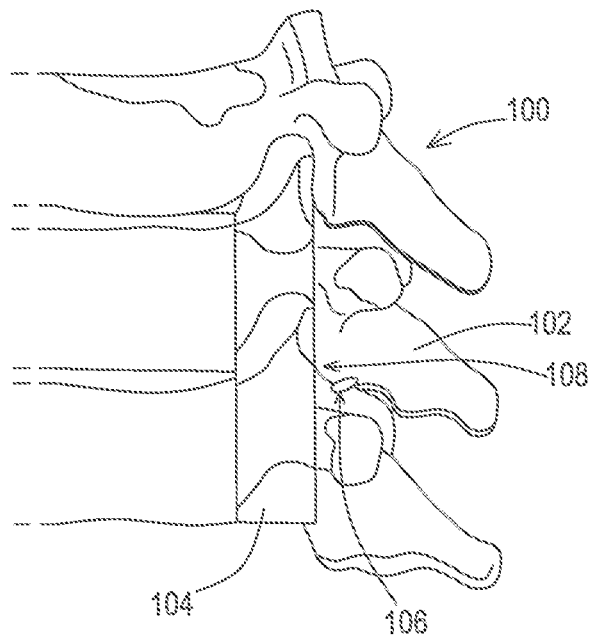


FIG. 1

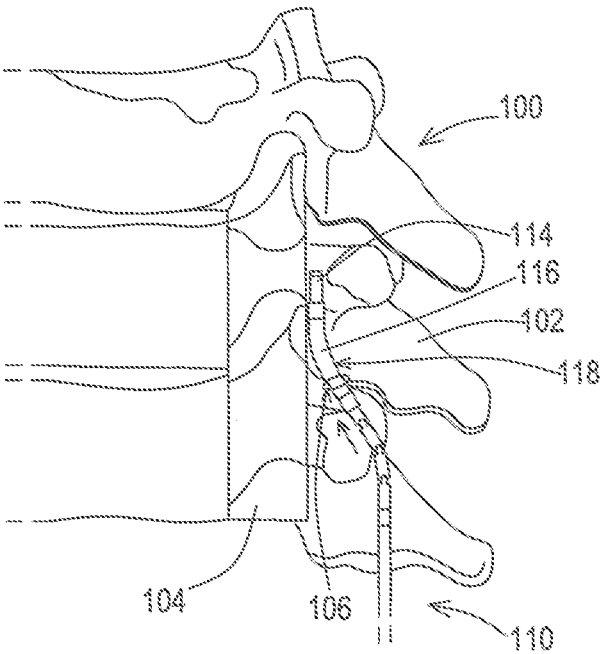


FIG. 2

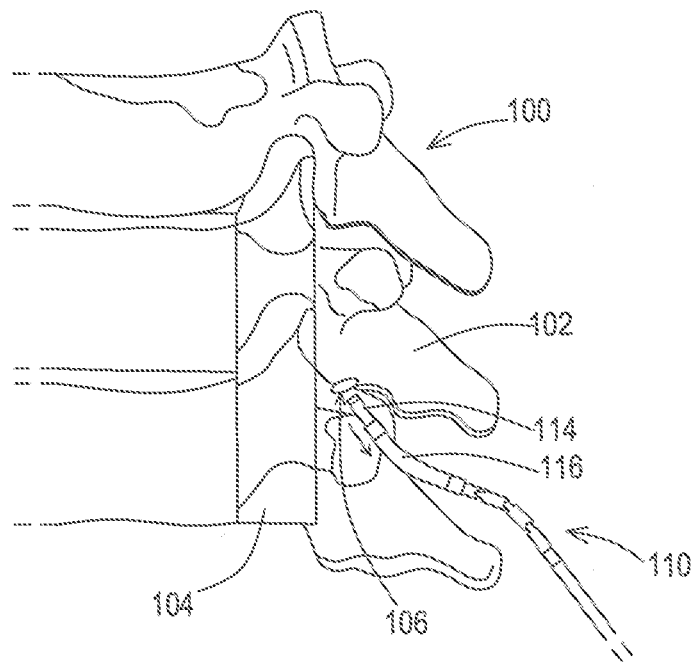


FIG. 3

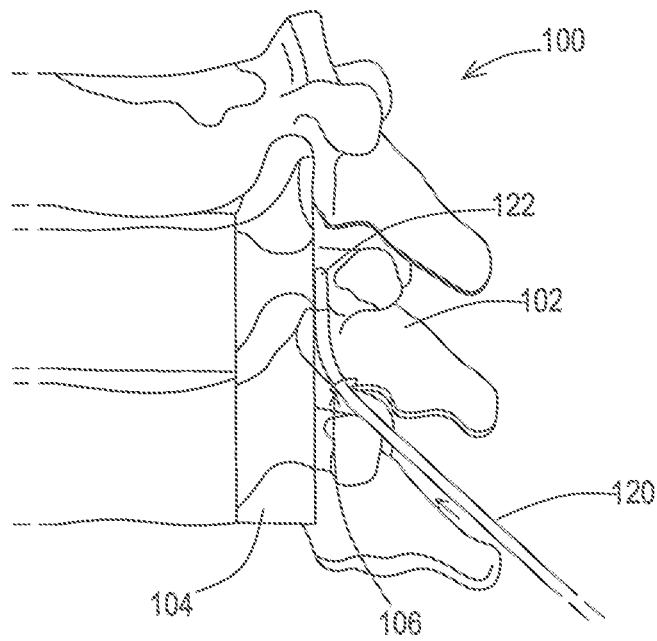
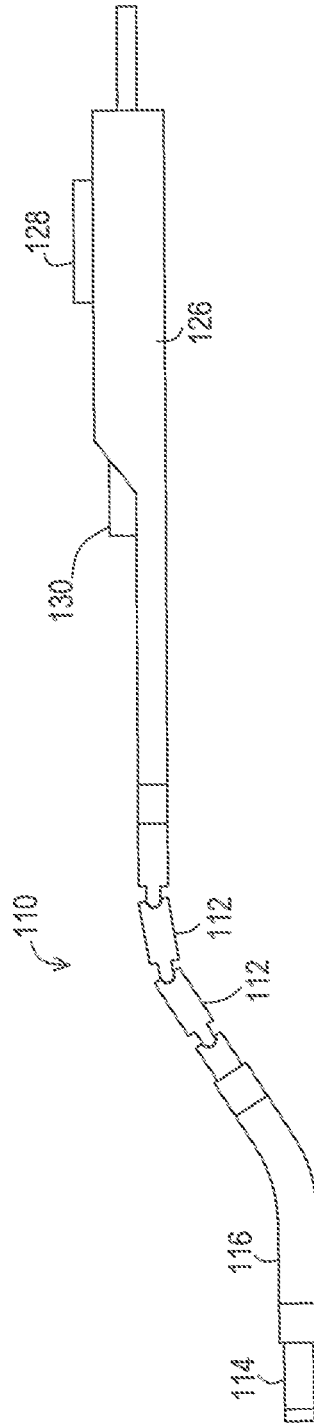


FIG. 4



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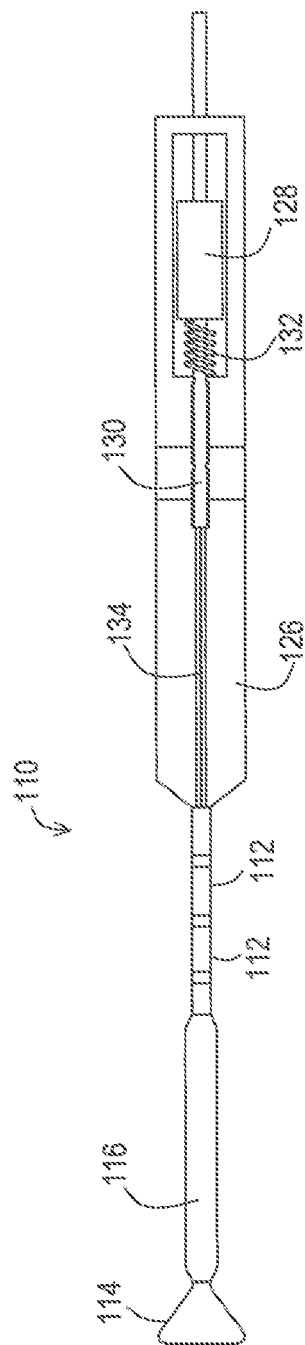


FIG. 5B

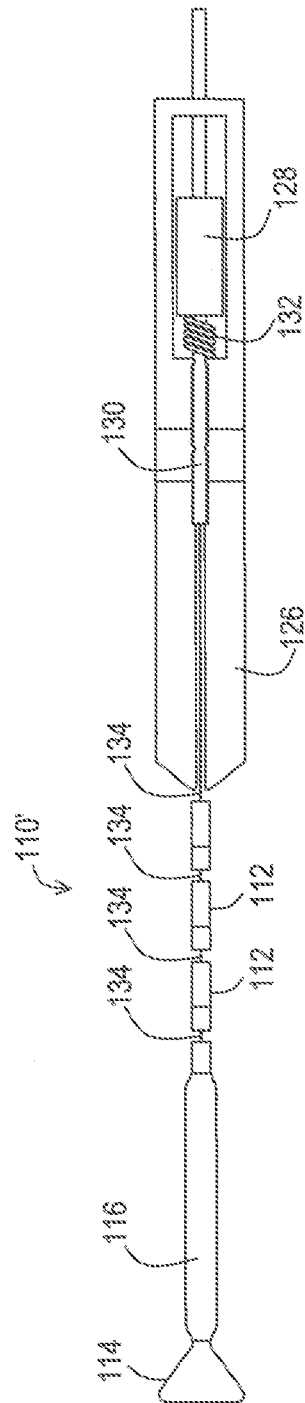


FIG. 5C

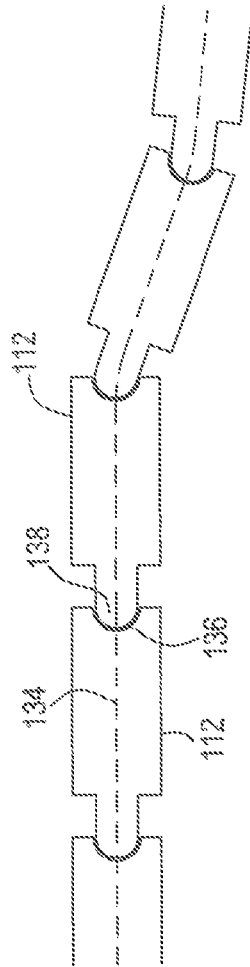


FIG. 6A

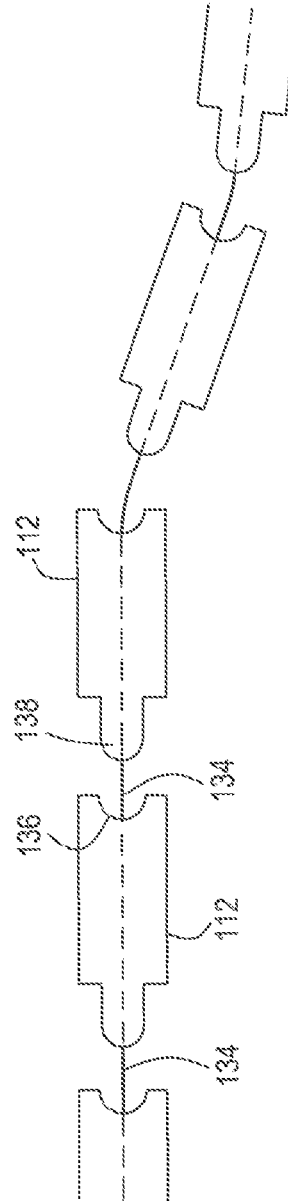


FIG. 6B



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# UTILIZING MULTIPLE LINKS TO ACHIEVE A DESIRED TOOL DEFLECTION ANGLE WHEN CLEARING AN EPIDURAL SPACE

## TECHNICAL FIELD

Embodiments are related to the implantation of medical leads used for stimulation within the epidural space. More particularly, embodiments relate to methods and tools that utilize multiple links to achieve a desired tool deflection angle when clearing the epidural space in preparation for implantation of a medical lead.

## BACKGROUND

Various medical conditions may call for therapeutic electrical stimulation within the epidural space of the spine. Therefore, medical leads capable of delivering stimulation signals are implanted within the epidural space. In some cases, it may be necessary to clear the epidural space as well as the entryway to the epidural space of fatty tissue, scar tissue, and the like in order to provide for easier ingress of the medical lead. This is particularly true for paddle leads that are implanted through a surgical procedure due to the relatively wide distal paddle on the medical lead.

Conventionally, a rigid plastic tool or a soft plastic tool is inserted into the epidural space through a window created within the vertebral bone and associated ligaments. However, the rigid plastic tool presents multiple issues. A first issue is that the rigid plastic provides minimal deflection when entering the epidural space at an angle through the window and thus creates a potential pressure point along the dura of the spinal cord which can cause discomfort and potential paralysis. Another issue is that once in the epidural space, the rigid plastic tool often has less than adequate clearing ability. The soft plastic also presents multiple issues. Once inside the epidural space the soft plastic may deflect in an undesired direction. Additionally, the soft plastic may not have the stiffness to track in the ideal direction. This is particularly true as the width and length of the paddle continues to grow with newer versions of paddle leads where the increased paddle width increases the likelihood of snagging the blockages within the epidural space. Furthermore, the rigid plastic tool with minimal deflection cannot enter at a shallow enough angle to allow for adequate insertion distance needed to reach and clear the target stimulation site.

## SUMMARY

Embodiments address issues such as these and others by providing multiple links within a clearing tool that are used to create a desired deflection angle for insertion and clearing within the epidural space. The links allow the deflection angle to be adjusted and locked by having a wire passing through the links that can be under tension to lock the deflection angle and released from tension when setting the deflection angle.

Embodiments provide a method of clearing an epidural space using a clearing tool that has at least two links. The method involves creating slack between the at least two links and establishing a desired angle between the at least two links. The method further involves tightening contact between the at least two links to lock the links at the desired angle as well as inserting the clearing tool through a window into the epidural space. Additionally, the method involves continuing to insert the clearing tool with the at least two links

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locked at the desired angle until a distal tip of the clearing tool at least reaches a target site and then removing the clearing tool through the window.

Embodiments provide a method of implanting a medical lead within an epidural space that involves creating slack between at least two links of a cleaning tool. The method further involves establishing a desired angle between the at least two links and tightening contact between the at least two links to lock the links at the desired angle. Additionally, the method involves inserting the clearing tool through a window into the epidural space and continuing to insert the clearing tool with the at least two links locked at the desired angle until a distal tip of the clearing tool at least reaches a target site. The method also involves removing the clearing tool through the window and after removing the clearing tool, inserting the medical lead through the window and into the epidural space.

Embodiments provide a clearing tool for preparing an epidural space for implantation of a medical lead. The clearing tool includes a handle with a biasing mechanism, the biasing mechanism being opposable. The clearing tool further includes a wire attached to the biasing mechanism such that the biasing mechanism creates tension on the wire and releases tension on the wire when a bias of the biasing mechanism is being opposed. Additionally, the clearing tool includes at least two links with the wire passing through each of the at least two links such that tension on the wire forces the at least two links into contact and includes a distal tip affixed to a most distal link.

## DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a spine with a window created to access the epidural space.

FIG. 2 shows an example of a clearing tool with multiple links being inserted into the epidural space while in a locked state.

FIG. 3 shows the clearing tool in the locked state being removed from the epidural space.

FIG. 4 shows the insertion of a medical lead into the cleared epidural space.

FIG. 5A shows a side view of an example of a clearing tool with multiple links in the locked state.

FIG. 5B shows a top view of the example of the clearing tool with multiple links in the locked state.

FIG. 5C shows a top view of the example of the clearing tool with multiple links in the released state.

FIG. 6A shows an enlarged side view of multiple links of the clearing tool in the locked state.

FIG. 6B shows an enlarged side view of multiple links of the clearing tool in the released state.

## DETAILED DESCRIPTION

Embodiments provide for methods and tools for clearing the epidural space in preparation for implantation of a medical lead within the epidural space. The clearing tool includes multiple links that can be used to form a desired deflection angle used when inserting the tool and clearing the epidural space. The multiple links may be forced into secure contact to lock the deflection angle and may be allowed to separate to release the deflection angle. When released, a different deflection angle may be established which may then be subsequently locked in place by again forcing secure contact of the links.

FIGS. 1-4 illustrate a method of clearing the epidural space and implanting the medical lead within the cleared epidural space. FIG. 1 shows a spinal region 100 of a patient where the

implantation of a medical lead is desired. Prior to clearing the epidural space **108**, a surgeon has created a window **106** in the spinal region **100** in the conventional manner by cutting through any vertebral bone and ligaments that block entryway to the epidural space **108** that occurs between the dura **104** of the spinal cord and the inner surface of the vertebral bone **102**.

FIG. 2 shows the insertion of the clearing tool **110** into the epidural space **108** by passing through the window **106** until the distal end of the clearing tool **110** becomes directed axially along the dura **104**. The clearing tool **110** includes a series of end-to-end links **112** creating a series of articulation points. In this example, a sleeve **116** is provided to further protect the dura **104** from direct contact with any individual link **112** present within a deflection area **118**. The deflection of the clearing tool **110** achieves alignment in the axial dimension of the dura **104**. This deflection is the result of angles established and secured between links **112** present in the deflection area **118**. The angles are created by the clinician manipulating the links **112** while in a released state and are then secured by a locked state. The creation of the deflection angle in the deflection area **118** ensures that the clearing tool **110** does not create undue pressure on the dura **104** when entering the epidural space **108**.

Additional angles may also be created between other links **112** of the clearing tool **110**. For example, links closer to a handle of the clearing tool **110** may create an angle that is opposite that of the deflection area **118** thereby creating a compound bend over the length of the clearing tool **110** so as to allow for movement of the handle of the clearing tool **110** in a direction parallel to the axial dimension of the spinal cord. Such an opposite angle and the relative positioning of the handle of the clearing tool **110** are discussed in more detail below in relation to FIG. 5A.

As an alternative to establishing the angle prior to insertion through the window **106**, the clearing tool **110** may be left in a released state during insertion so as to allow the links **112** to achieve a naturally induced deflection angle. Then, upon the distal tip **114** being fully inserted and aligned with the axial dimension of the spinal cord, the clearing tool **110** may be transitioned to the locked state to lock the deflection angle and create rigidity among the links **112** to allow for additional insertion and clearing of the epidural space **108**.

The clearing tool **110** including each of the links **112** as well as the handle discussed below may be constructed of various materials such as acetel, polypropylene, polyethylene, or nylon (polyamide). The sleeve **116** may be made of a flexible, elastic material such as silicone rubber that can fit relatively tightly over the links **112** so as not to slide on the links **112** during insertion. To aid the clearing process, the links **112** and/or sleeve **116** of the clearing tool **110** may also be made radiopaque by including materials such as barium sulfate, and/or tungsten so as to be visible during fluoroscopy.

Once the distal tip **114** has been advanced within the epidural space **108** to the target site, the clearing tool **110** may be retracted back through the window **106**. The retraction of the clearing tool **110** is shown in FIG. 3. While the clearing tool **110** is being retracted, the links **112** of the clearing tool **110** may be transitioned to the released position to provide flexibility and the ability to freely deflect as needed for removal within the epidural space **108** in proximity to the window **106**. The clearing tool **110** is directed out through the window **106** while the deflection area **118** continues to avoid undue pressure on the dura **104**.

Once the clearing tool **114** has been removed from the spinal region **100**, the medical lead **120** is then inserted through the window **106** and into the epidural space **108** as shown in FIG. 4. The medical lead **120** continues to be

inserted until a distal end such as a paddle **122** of the medical lead **120** reaches the target stimulation site along the axial dimension of the dura **104**. Afterward, the medical lead **120** is connected to a medical device that delivers the electrical stimulation signals that are output through electrodes in the distal end of the medical lead **120**. As shown in FIG. 4, the body of the medical lead **120** may exceed that of the links **112** and sleeve **116** of the clearing tool **110**, but the width of the distal tip **114** of the tool **110** has cleared the epidural space **108** so that the additional width of the medical lead **120** and the distal end **122** are not blocked during ingress by obstructions.

FIG. 5A shows a side view of the clearing tool **110** where multiple deflections have been established prior to insertion into the epidural space. The most distal links **112** which are present beneath the sleeve **116** are angled relative to adjacent links to create a deflection suitable for the distal end to enter the epidural space. The most proximal links **112** are angled oppositely relative to adjacent links as compared to angle between the most distal links to create a deflection that aligns the handle **126** with the axial dimension of the spinal cord. Thus, while inserting the distal end of the clearing tool **110** into the epidural space, a slight rotation of the proximal end in relation to the distal end of the handle **126** toward the spine to achieve alignment to the axial dimension of the spinal cord effectively aims the distal tip **114** parallel to the axial dimension of the spinal cord as well. Therefore, the advancement of the distal tip **114** during insertion of the clearing tool **110** while rotating the handle **126** as prescribed further avoids undue pressure on the dura **104**.

The clearing tool **110** further includes a slider **128** that can be manipulated to establish the locked or released states of the links **112**. The slider **128** includes guide posts **130** that retain the slider **128** within the handle **126** as the slider **128** is being moved in the proximal or distal directions. The top view of FIGS. 5B and 5C further show the relationship of the slider **128** and guideposts **130** to the handle **126** in both the locked state in FIG. 5B and the released state in FIG. 5C.

In FIG. 5B, the locked state is achieved by a bias being applied to the slider **128** by a biasing mechanism such as the spring **132**. While the biasing mechanism is shown as a coil spring **132**, other biasing mechanisms are possible such as leaf springs. In this example, the spring **132** is present about the guidepost **130** of the slider **128** and abuts the handle **126** on one end and the slider **128** on the other. The spring **132** of this example biases the slider **128** in the proximal direction to impose the locked state upon the links **112** by creating tension on a wire **134**. The proximal end of the wire **134** is attached to the slider **128** and/or guidepost **130** while the distal end of the wire **134** is attached to a most distal link **112** or the distal tip **114**. As shown in FIG. 5C, a clinician applies force to the slider **128** in the distal direction to decrease the tension on the wire **134** and thereby impose the released state on the links **112**, creating slack between each of the links **112** so that each is free to rotate several degrees relative to adjacent links **112**.

In this particular example of FIGS. 5A-5C, when in the released state the links **112** are configured to achieve angles relative to adjacent links within a single geometric plane, namely the plane perpendicular to the back of the patient and parallel with the axial dimension of the spine. However, in this example the links **112** are maintained in a linear arrangement in the geometric plane of the back of the patient to avoid the links **112** from diverting laterally from the axial dimension of the spine. This is achieved by having links **112** with a concave end and a convex end such that a concave end of one link **112** engages a convex end of an adjacent link **112** that restricts relative movement to the single geometric plane.

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The engagement of a convex end with a concave end as in FIG. 5A is also shown in the enlarged view of the links 112 in FIGS. 6A and 6B. In this example, the distal end of each link 112 is convex while the proximal end is concave. However, it will be appreciated that the configuration may be reversed, with the distal end being concave and the proximal end being convex to achieve the same articulation points.

Furthermore, it will be appreciated that there may be applications where it is desirable to create deflections in other geometric planes than the plane shown in FIGS. 5A-5C, 6A, and 6B. For instance, side entry procedures may benefit from deflection lateral to the axial dimension of the spine in addition to deflection in the plane shown in FIG. 5A. In such cases, embodiments of the clearing tool 110 may instead have ball and socket engagements between links 112 that allow for more degrees of freedom of movement, and hence an articulation in any desired geometric plane.

FIGS. 6A and 6B further illustrate the wire 134 used to hold the links 112 together and to impose the locked and released states. The wire 134 passes through a hole within each link 112 that extends from the proximal end to the distal end. When the wire 134 is under tension by the slider 128 as in FIG. 6A, the links 112 are brought into tight contact with one another that prevents further movement due to stiction between the engaged links 112. When tension on the wire 134 is decreased or removed altogether as in FIG. 6B, the tight contact between the links 112 is removed to create slack between the links 112 that allows the links 112 freedom of movement relative to one another.

The wire 134 may be a flexible single strand or may be flexible yet cabled, braided, and the like to increase tensile strength. Additionally, the wire 134 may be constructed of various biocompatible materials. For instance, in one embodiment the wire 134 is stainless steel. In another embodiment, the wire 134 is constructed of polyester.

While embodiments have been particularly shown and described, it will be understood by those skilled in the art that various other changes in the form and details may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. A method of clearing an epidural space using a clearing tool that has at least two links, comprising:

creating slack between the at least two links;  
establishing a desired angle between the at least two links;  
tightening contact between the at least two links to lock the links at the desired angle;

after tightening contact between the at least two links, inserting the clearing tool through a window into the epidural space while the at least two links are locked at the desired angle;

continuing to insert the clearing tool while the at least two links are locked at the desired angle until a distal tip of the clearing tool at least reaches a target site; and  
removing the clearing tool through the window.

2. The method of claim 1, wherein creating slack between the at least two links comprises releasing tension on a wire that passes through the at least two links.

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3. The method of claim 2, wherein releasing tension on the wire comprises opposing a bias being applied on the wire by a spring.

4. The method of claim 3, wherein applying tension on the wire comprises applying the bias on the wire by the spring.

5. The method of claim 2, wherein tightening contact between the at least two links comprises applying tension on the wire.

6. The method of claim 1, further comprising covering the at least two links with a sleeve.

7. The method of claim 1, wherein the at least two links comprise three links, and wherein establishing the desired angle between the at least two links comprises establishing a first desired angle between a first link and an adjacent second link and establishing a second desired angle between the second link and an adjacent third link.

8. The method of claim 7, wherein the first angle is opposite the second angle.

9. A method of implanting a medical lead within an epidural space, comprising:

creating slack between at least two links of a cleaning tool;  
establishing a desired angle between the at least two links;  
tightening contact between the at least two links to lock the links at the desired angle;

after tightening contact between the at least two links, inserting the clearing tool through a window into the epidural space with the at least two links locked at the desired angle;

continuing to insert the clearing tool with the at least two links locked at the desired angle until a distal tip of the clearing tool at least reaches a target site;

removing the clearing tool through the window; and  
after removing the clearing tool, inserting the medical lead through the window and into the epidural space.

10. The method of claim 9, wherein creating slack between the at least two links comprises releasing tension on a wire that passes through the at least two links.

11. The method of claim 10, wherein releasing tension on the wire comprises opposing a bias being applied on the wire by a spring.

12. The method of claim 11, wherein applying tension on the wire comprises applying the bias on the wire by the spring.

13. The method of claim 10, wherein tightening contact between the at least two links comprises applying tension on the wire.

14. The method of claim 10, further comprising covering the at least two links with a sleeve.

15. The method of claim 10, wherein the at least two links comprise three links, and wherein establishing the desired angle between the at least two links comprises establishing a first desired angle between a first link and an adjacent second link and establishing a second desired angle between the second link and an adjacent third link.

16. The method of claim 15, wherein the first angle is opposite the second angle.

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